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Two step electrodialytic remediation of soil suspension for simultaneous removal of As and Cu

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Introduction

Simultaneous removal of As and Cu from soil during electrochemical treatment is not straightforward. To have successful, simultaneous removal As and Cu they must desorb during the remediation process and be present in ionic form in the soil solution. Cu is in ionic form in an acidic environment regardless oxidation status of the soil. As is also desorbed under acidic conditions [1,2], but the redox status is highly important for the As speciation. Table 1 shows a generalized pattern for Cu and As being charged and mobile for electromigration under different pH and redox conditions.

Table 1. Generalized pattern for Cu and As speciation

pH	Redox	Cu	As
Acidic	Low	Ionic form	As(III) uncharged
Alkaline	High	Precipitated	As(V) charged
Acidic	High	Ionic form	As(V) uncharged highly acidic, charged moderately acidic
Alkaline	Low	Precipitated	As(III) uncharged moderately until slightly alkaline, charged highly alkaline

Without use of assisting agents it is not possible to remove Cu from the soil. Under acidic conditions it is only possible to remove As at in an environment with high redox potential at a moderately low pH as (H_2AsO_4^-). The present work is focused on obtaining such optimal condition for electroremediation by a two-step electrodialytic method. Figure 1 shows the two steps tested in the present investigation.

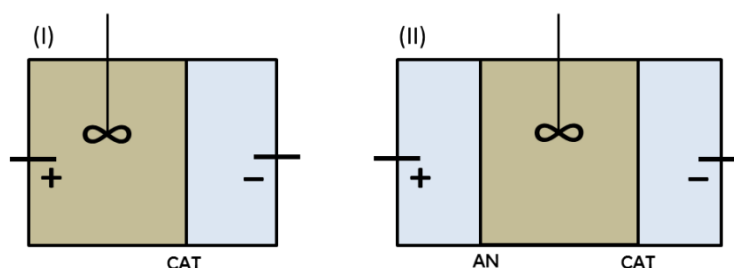


Figure 1. The two steps for simultaneous As and Cu removal. The anode is first placed directly in the soil suspension (I) and after a period of time a separate anode compartment is added.

In the first step (2C) the anode is placed directly into the soil suspension. The anode process $\text{H}_2\text{O} \rightarrow 2\text{H}^+ + \frac{1}{2} \text{O}_2 (\text{g}) + 2\text{e}^-$ will result in an acidic environment with a high redox potential just as needed for the simultaneous removal of As and Cu. Cu is removed into the catholyte in setup (I), but As remains dissolved in the suspension in 2C, thus the second step (2C-3C) is needed for a separation of As into the anolyte.

In the preliminary test of the two-step electrochemical remediation two experiments were conducted with soil sampled at a wood preservation site. Initial concentrations were 710 mg As/kg and 1500 mg Cu/kg. The experiments were:

- 2C; Cell (I) for 2 days
- 2C-3C; Cell (I) for 2 days and cell (II) for 7 days

The experimental cells were cylindrical (internal diameter 8 cm, length of electrode compartments 5 cm and compartment with ash suspension 10 cm) The ion exchange membranes were from Ionics. The platinum coated electrodes from Permascand. A constant current of 10 mA was applied. Circulating in the electrode compartments 500 mL adjusted to pH 2 with HNO₃. The soil was kept suspended by an overhead stirrer. During the experiments, the pH was adjusted manually in the cathode compartment to between 1 and 2 once a day with 1 M HNO₃. A constant current of 10 mA was applied.

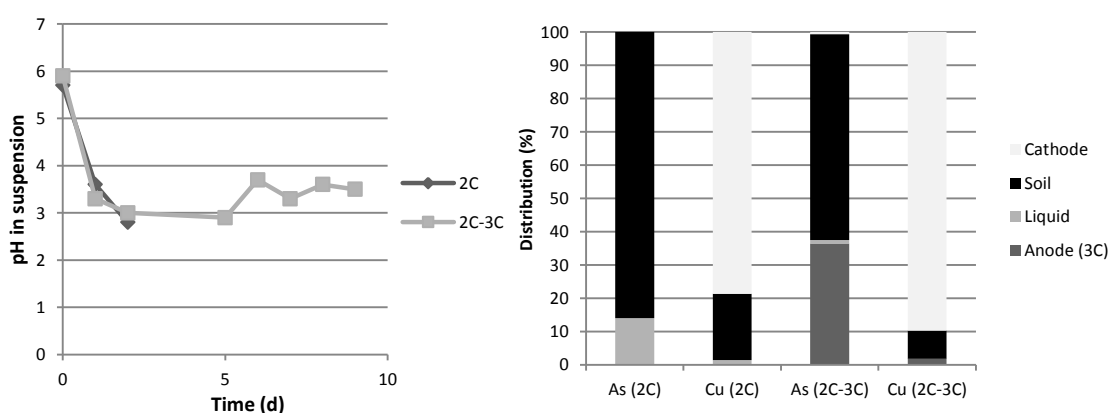


Figure 2. (a) pH of the soil suspension in the experiments and (b) Distribution of Cu and As in the system after the two experiments.

Overall results from the experiments are in figure 2. During two days in 2C pH decreases from 6 to 3 and after adding the anode compartment to the cell (2C-3C) pH remains rather stable at 3.5 (fig. 2a). The distribution of As and Cu at the end of experiments (fig. 2b) shows that after two days in 2C, the major fraction of As is still adsorbed, whereas already after 2 days 80% Cu was removed into the catholyte, and the Cu remediation was actually sufficient to reach the Danish limiting value. When combining 2C and 2C-3C As desorption continued during the 3C period, and almost all desorbed As was transported into the anolyte. However, 64% As remained in the soil.

This initial result is encouraging. The Cu remediation already finished after 2 days in 2C. Too little As was desorbed, but the separation of dissolved As into the anolyte was very efficient. As desorption is only sufficient (90-100%) at pH of about 1 in a suspension [1, 2] so in coming experiments the period in 2C will be longer to reach this pH. In the following 3C the aim is then first to remove H⁺ into the catholyte in the applied electric field, so suspension pH increases to a level, where As is mobile.

References

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